Bank competition with product differentiation under different monetary policy rules

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Abstract

Applying the Salop model of competition with product differentiation to banks, we analyze the effects on bank competition of the choice of a monetary policy rule by the central bank. We show that a countercyclical monetary policy may imply a countercyclical movement of the number of active banks, i.e. a level of bank competitiveness that varies over time. With respect to competition policy, this indicates that a lack of competition in the banking sector at some point in time cannot always be blamed on the abuse of market power by banks; it may have its roots in the interest rate setting rule chosen by the central bank.

Keywords: Monopolistic competition; Banks; Monetary policy.

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1 Introduction

Empirical evidence suggests that European banking sectors are characterized by monopolistic competition. For example, Molyneux et al. (1994) argue that '... bank revenues appear to be earned as if under monopolistic competition...' (p. 454) for Germany, the UK, France, and Spain. De Bandt and Davis (2000) present similar results for European banking markets, in particular for large banks. Finally, Bikker and Groeneveld (2000) provide evidence of monopolistic competition both in the overall European Union banking industry and in individual European banking markets. This finding of monopolistic competition generally refers to the fact that the authors can reject the hypothesis of perfect competition as well as that of monopoly power. Therefore, in order to assess the effects on the level of bank competition of different monetary policy rules - or, more specifically, possible effects of Economic and Monetary Union (EMU) implementation and the European Central Bank's (ECB's) policy criteria with respect to the cost of credit - oligopoly models seem to be the natural starting point. For example, one could assume heterogeneous products (i.e. loans) and make use of a theoretical model of monopolistic competition with product differentiation.

Bagliano et al. (2000) examine the possible effects of the ECB's monetary policy on bank competition in the context of pricing behavior of banks over the business cycle. They describe monetary policy by an interest rate setting rule that can have both a countercyclical and a stochastic component. Note that the central bank itself knows its own reaction function and therefore, from the point of view of the central bank, the latter component is not stochastic. However, from the point of view of the public (e.g. the banks), the interest rate setting rule may well contain a stochastic component representing unknown policy goals and thus this is the relevant specification for the analysis of effects of different monetary policy rules on bank behavior.

Using a model of implicit collusion among banks, Bagliano et al. discuss the effects of the choice of a monetary policy rule by the central bank on collusion and the incentive of banks to set high lending rates over the business cycle. The present paper uses a similar interest rate setting rule to study the effects of monetary policy on bank competition. However, we use a different model of competition, based on product differentiation. In the particular model of Bagliano et al. there is always perfect collusion in bad states of the world, independent of the central bank's policy rule. The choice of policy rule therefore only affects bank competitiveness in good states. In contrast, we present a model in which monetary policy affects bank behavior both in good states and in bad states.

The concept of monopolistic competition is based on the idea that with differentiated products, the results of price competition among firms are less extreme than in the standard Bertrand model. We use a popular model of monopolistic competition that was introduced by Salop (1979). In the original model, products are differentiated because of geographical distance and transportation costs. The model has been applied to the banking sector by various authors, for example to assess the optimal number of banks or the effects of deposit rate regulation (see Freixas and Rochet, 1997, pp. 67-73).

A recent contribution to the banking literature based on the Salop model of monopolistic competition is that of Schargrodsky and Sturzenegger (2000), in which the effect of prudential regulation (aiming at increased solvency) on bank competition is examined. They interpret product differentiation as banks specializing in different geographic or economic areas, and assume the degree of specialization (the transportation cost parameter of the original Salop model), to be endogenous. In that case, they show that tighter capital requirements imply a lower degree of specialization, which may induce more intense competition. This result contradicts the traditional prediction of a trade-off between solvency and competition.

In contrast to this approach, we let the degree of product differentiation be exogenous as in the original Salop model. As in Bagliano et al. (2000), we introduce uncertainty with respect to economic conditions. This enables us to assess the effects of different (possibly countercyclical) monetary policy rules that a central bank may choose on the level of bank competition in a product differentiation setting.

The remainder of this paper is structured as follows. Section 2 gives the basic setup of the model. It describes the policy goals of the central bank and presents a simple model of monopolistic competition for the banking sector based on the Salop model. Section 3 derives the solution of the model. In particular, we examine the effects of the choice of a specific monetary policy rule by the central bank on the competitiveness of the banking sector. In Section 4 we discuss the interpretation of the model in more detail and present some extensions. Section 5 concludes.

2 The model

The setup of the model is as follows. In stage 1, the central bank decides on the policy rate according to some interest rate setting rule that describes monetary policy. In stage 2, the banks decide whether or not to be active in the market in the next stage. Finally, in stage 3, the active banks compete by setting interest rates for loans and lending to entrepreneurs. This section starts with a short description of monetary policy (stage 1) and proceeds with the model of bank competition (stages 2 and 3) which is based on the Salop model.

In general, a central bank is concerned with two important issues: the current output level y relative to the trend output level $\overline{y}$, and current inflation π relative to steady-state inflation $\overline{\pi}$. According to the well-known Taylor rule (Taylor, 1993), the desired interest rate satisfies

$$i = \bar{i} + \overline{\pi} + \phi_\pi (\pi - \overline{\pi}) + \phi_y (y - \overline{y}),$$

where $\bar{i}$ refers to the steady-state interest rate and ϕ_π, ϕ_y are parameters. In the present paper, we ignore inflation for expositional convenience. This leaves us with the simplified Taylor rule

$$i = \bar{i} + \phi_y (y - \overline{y})$$

with $\phi_y > 0$, a countercyclical interest rate setting rule based on the output level.

In the present paper monetary policy follows a modified version of this Taylor rule, derived in more detail in the next section. For now, we only state that the central bank aims at stabilizing output around its natural level to some (exogenous) extent. The resulting policy rule that determines i depends on the size of an economy-wide shock described below, which is assumed to be observed by the central bank. Also, we include a component that represents unanticipated deviations from the countercyclical policy rule, that can be interpreted as policy rate adjustments aiming at possible other goals. Note that the central bank in our model does not choose a specific strategy in order to maximize some explicit payoff function. Instead, the description of central bank behavior is more general and allows for a variety of objective functions that are not specified explicitly. It resembles a (modified) Taylor rule, as in Bagliano et al. (2000). This general specification allows us to examine the effects of different policy rules on the degree of competition of the banking sector.

With respect to the bank competition subgame of stages 2 and 3, consider a Salop circular city of length 1, on which there is a unitary density of entrepreneurs located uniformly along the circle. We consider product differentiation among banks. That is, each bank offers a single product only, i.e. loans of a specific type. The type of loan offered by the bank is indicated by the bank's location on the circle. Thus, loans are heterogeneous among banks. We interpret a specific location of an entrepreneur on the circle as the entrepreneur's taste for a specific type of loan. Entrepreneurs can undertake an investment project of fixed size normalized to 1. In order to invest, they need to borrow from a bank. There are n banks, located symmetrically along the circle. An entrepreneur l, located at distance x_{lj} from bank j, is x_{lj} away from his preferred type of loan when borrowing from bank j. Let t be a taste parameter, which is the analog of a transportation cost. Then, tx_{lj} expresses (the monetary equivalent of) the entrepreneur's disutility of not obtaining his preferred type of loan. Apart from a fixed entry fee F, there is free entry in the banking sector. Generally, the deposit rate closely follows the money market or policy rate. Therefore, we use the common assumption that each bank faces an infinitely elastic deposit supply at the nominal short-term interest rate i.

The timing of the bank competition subgame is as follows. In stage 2, given i, banks decide on entry. That is, the number of active banks n is determined. In stage 3, the n banks decide on the interest rates on loans a_j, $j = 1, ..., n$. Then, each entrepreneur borrows from the bank he prefers. After obtaining loans, entrepreneurs are subject to an economy-wide shock. Finally, total repayments obtained by the bank depend on the shock and are used to repay depositors.

Again consider entrepreneur l, located at distance x_{lj} from bank j. Without the shock, by borrowing from bank j and investing the loan, this entrepreneur obtains

$$S_{lj} = V - a_j - tx_{lj}, \tag{1}$$

where V denotes the gross returns of the investment project. We assume that the market for loans is covered, that is, each entrepreneur obtains a loan at some bank and has $S_{lj} \geq 0$. In Section 4.2 we discuss an extension in which this assumption does not hold and some entrepreneurs prefer not to borrow. Expression (1) is sometimes referred to as the entrepreneur's utility. However, since the entrepreneur is not a consumer but is a producer himself, we prefer not to use this definition. Alternatively, interpreting V as the value of sales that can be obtained by investing (*not* corrected for the cost of obtaining the loan), S_{lj} denotes the (net) value of sales generated by the investment.

Economic conditions affect the actual sales level. For example, aggregate demand may turn out to be low and some entrepreneurs may go bankrupt. The economy-wide shock s is therefore assumed to affect the entrepreneurs' sales in the following way. If the shock turns out to be s, a fraction $1-s$ of the entrepreneurs (selected randomly) goes bankrupt and gets zero. Note that we assume that the entrepreneurs have limited liability and no collateral; if an entrepreneur goes bankrupt, he does not repay the principal nor the interest. Therefore, for a given shock s, for entrepreneur l the expected value of sales generated by the investment is given by

$$sS_{lj} = s\left(V - a_j - tx_{lj}\right).$$

This can be interpreted as the expected value of sales for given economic conditions. We assume s to be uniformly distributed on the interval $[0,1]$.

The actual realization of s is assumed to be unknown to the public (i.e. commercial banks) in stages 2 and 3. However, the desired interest rate i determined in stage 1 depends on the realization of the shock s. We thus assume the realization of s to be observed by the central bank but not by the public. This may not seem a realistic assumption, in particular since the banks may be able to infer the value of s observed by the central bank from the policy rate i it sets in stage 1. We will discuss this possibility as an extension in Section 4.1. In the next section, we assume for simplicity that s is known to the central bank but not to commercial banks.

3 Solution of the model

In order to solve for the equilibrium of the model, we apply backward induction. Starting with stage 3, we take i and n as given. The distance between two banks is given by $\frac{1}{n}$. The indifferent entrepreneur between two adjacent banks j and k is therefore located at $\widehat{x}$ such that

$$V - a_j - t\widehat{x} = V - a_k - t\left(\frac{1}{n} - \widehat{x}\right)$$

implying

$$\widehat{x} = \frac{-a_j + a_k + \frac{t}{n}}{2t}.$$

The assumption that the market is covered can thus be written as $V - a_j - t\widehat{x} \geq 0$ for all j. Assuming symmetry among banks, all banks other than j will set the same lending rate a_{-j}, and total demand faced by bank j when it sets rate a_j is given by

$$D_j\left(a_j, a_{-j}\right) = 2\widehat{x} = \frac{-a_j + a_{-j} + \frac{t}{n}}{t}.$$

Evidently, with the specification of the shock to entrepreneurs' sales as described in the previous section, the shock will also affect the banks' earnings. Without limited liability for banks, bank j's earnings are given by

$$s\left(1 + a_j\right) D_j\left(\cdot\right) - \left(1 + i\right) D_j\left(\cdot\right).$$

This should be interpreted as a fraction $1-s$ of entrepreneurs going bankrupt and not repaying anything. Imposing limited liability for banks, bank j's profits will be zero whenever $s\left(1 + a_j\right) - \left(1 + i\right) \leq 0$, implying that bank j's expected profits are

$$\begin{aligned} E\left(\pi_j\right) &= \int_{\frac{1+i}{1+a_j}}^{1} \left[s\left(1 + a_j\right) D_j\left(\cdot\right) - \left(1 + i\right) D_j\left(\cdot\right)\right] ds \\ &= \frac{1}{2} D_j\left(\cdot\right) \frac{\left(a_j - i\right)^2}{1 + a_j}. \end{aligned}$$

In this stage, each bank j maximizes expected profits $E(\pi_j)$ with respect to a_j, taking i and n as given. The first-order condition is given by

$$\begin{aligned}\frac{dE(\pi_j)}{da_j} &= \frac{1}{2}D_j(\cdot)\frac{2(a_j-i)(1+a_j)-(a_j-i)^2}{(1+a_j)^2} \\ &- \frac{1}{2t}\frac{(a_j-i)^2}{1+a_j}=0.\end{aligned}$$

Imposing symmetry and solving for a, we find the equilibrium lending rate

$$a^* = \frac{1}{2n}\left[t-n+ni+\sqrt{t^2+n^2+6nt+2n^2i+n^2i^2+6nit}\right]. \tag{2}$$

It can be shown that the second-order condition for a maximum (which is not reproduced here) is satisfied as long as t is sufficiently small.

In stage 2, banks will enter as long as expected third-stage profits are larger than the entry fee F. We disregard indivisibilities (i.e. the fact that n is an integer). Taking i as given and using the equilibrium lending rate from the analysis of stage 3, the equilibrium value of n should satisfy

$$E(\pi^*) = \frac{1}{2n}\frac{(a^*-i)^2}{1+a^*} = F.$$

This condition can be rewritten as

$$\left(t-n-ni+\sqrt{X}\right)^2 - 4n^2F\left(t+n+ni+\sqrt{X}\right) = 0, \tag{3}$$

where

$$X \equiv t^2+n^2+6nt+2n^2i+n^2i^2+6nit.$$

This condition for second-stage equilibrium implicitly defines the equilibrium number of banks n^* as a function of i and the parameters of the model. We do not present an explicit formula for n^* because it is lengthy and not needed for further analysis.

Before discussing the analysis of the first stage, we present two lemma's that describe the effect of a change in i on n^* and a^*, respectively.

Lemma 1 *The equilibrium number of banks is negatively related to the short-term interest rate:* $\frac{dn^*}{di} < 0$.

Proof. See the Appendix. ■

Lemma 2 *The equilibrium lending rate is positively related to the short-term interest rate:* $\frac{da^*}{di} > 0$.

Proof. See the Appendix. ■

Now we turn to stage 1. In this stage, the central bank realizes that expected[1] total output y at the end of stage 3 is given by the integral of the expected sales values of all entrepreneurs, which can be written as

$$y = \int_{l=0}^{1} sS_{lj} \mathrm{d}l = s \int_{l=0}^{1} (V - a^* - tx_{lj}) \, \mathrm{d}l \equiv sI.$$

The integral $I = I(a^*(i))$ is a decreasing function of a^*, that is, a decreasing function of i. Assuming that the central bank knows the realization of s, we can derive the policy rule followed by the central bank in the setting of this output specification. The central bank is assumed to aim at stabilizing output (to some exogenous extent) around its natural level $\overline{y} = \overline{s}I(\overline{i})$. For simplicity, we set the size of the shock associated with the natural output level $\overline{s}$ at $\frac{1}{2}$. Intuitively, in case of a shock $s > \frac{1}{2}$ that causes output to be relatively high ceteris paribus, the central bank sets $i > \overline{i}$, reducing I and thereby reducing output towards $\overline{y}$. In case of a shock $s < \frac{1}{2}$ that causes output to be low, the central bank sets $i < \overline{i}$, stimulating output. More precisely, monetary policy can be described by the interest rate setting rule $i = \overline{i}[1 + \alpha(2s - 1)]$, $\alpha \geq 0$. Here, s refers to the economy-wide shock and $\overline{i}$ denotes the 'average' short-term interest rate. The parameter α is

[1] We refer to *expected* output here, because although s is assumed to be known, it is uncertain which entrepreneurs will go bankrupt. The central bank only knows the fraction of entrepreneurs that will go bankrupt.

a feedback coefficient indicating to what extent the central bank stabilizes output. Adding a component ε to account for unanticipated deviations from the policy rule (for example responses to foreign shocks), the general interest rate setting rule is given by

$$i = \bar{i}\left[1 + \alpha\left(2s - 1\right)\right] + \varepsilon. \tag{4}$$

The component ε is interpreted by the banks as a stochastic component that is independently and identically distributed with mean zero and constant exogenous variance. Evidently, the central bank knows its own reaction function and therefore for the central bank, ε is not random.

Writing the monetary policy rule in this way, the central bank's policy is based on the level of s. Observe that the central bank moves the short-term interest rate countercyclically if $\alpha > 0$: in good states of the world, i.e. for $\frac{1}{2} < s \leq 1$, $\alpha\left(2s - 1\right)$ is positive, whereas in bad states, where $0 \leq s < \frac{1}{2}$, this term is negative. Note that this monetary policy rule is more general than the one that would derive from the straightforward maximization of output stability. That approach would specify a value for α and would have $\varepsilon \equiv 0$. In this more general specification, the central bank is concerned with output stability (to some extent) as well as with other possible objectives. This allows for the analysis of the effects of different monetary policy rules on bank competitiveness.

3.1 Effects of monetary policy

We will examine two polar cases of the interest rate setting rule (4): purely stochastic interest rate setting ($\alpha = 0$) and purely countercyclical interest rate setting ($\varepsilon \equiv 0$). Observe that the former 'rule' is not a realistic case; we only discuss it here to analyze the effects of changes in ε, so that we can omit ε for expositional convenience in the discussion of the countercyclical rule. As in Bagliano et al. (2000), the results allow us to derive some possible implications for the effects of ECB's monetary policy on bank competition in national EMU credit markets.

3.1.1 Stochastic interest rate setting

In the case of purely stochastic interest rate setting, from the point of view of the public monetary policy can be described by

$$i = \bar{i} + \varepsilon. \tag{5}$$

Proposition 1 *$\frac{dn^*}{d\varepsilon} < 0$ and $\frac{da^*}{d\varepsilon} > 0$. A deviation $\varepsilon > 0$ from the average rate $\bar{i}$ implies less banks and higher lending rates.*

Proof. The proof is straightforward and follows from Lemma's 1 and 2 and (5) directly. ■

This proposition shows that a deviation $\varepsilon > 0$ implies less intense competition (less banks). This corresponds to Proposition 4 of Bagliano et al. (2000), which shows that in their model $\varepsilon > 0$ implies that banks are more likely to collude and that the collusion lending rate is higher.

With fixed exchange rates country-specific shocks may have spillovers on other countries (see also Bagliano et al., 2000, pp. 976-977). For example, under the European Monetary System (EMS), shocks to the German economy sometimes forced other member countries to adjust their interest rates as well in order to defend the parity of their currency. This type of interest rate adjustment following a shock in a foreign country is captured by ε in our model. Therefore, ε may have been relatively large (in absolute value) for member countries other than Germany, and the shift to EMU may imply smaller ε for those countries and larger ε for Germany. According to the above result, this would induce an increase in the variability of bank competitiveness and the lending rate for Germany, but a decrease in these variabilities for the other member countries.

3.1.2 Countercyclical interest rate setting

With purely countercyclical interest rate setting, the central bank determines i according to

$$i = \bar{i}\left[1 + \alpha\left(2s - 1\right)\right]. \tag{6}$$

Proposition 2 *For $\frac{1}{2} < s \leq 1$, $\frac{dn^*}{d\alpha} < 0$ and $\frac{da^*}{d\alpha} > 0$. For $0 \leq s \leq \frac{1}{2}$, $\frac{dn^*}{d\alpha} \geq 0$ and $\frac{da^*}{d\alpha} \leq 0$. An increase in α increases the degree of countercyclicality of both n^* and a^*.*

Proof. Note that in (6) an increase in α implies higher i if $s > \frac{1}{2}$, but lower i if $s < \frac{1}{2}$. Using Lemma's 1 and 2, this proves the first part of the proposition. For the second part, define the values of n^* and a^* corresponding to $i = \bar{i}$ by $\overline{n}$ and $\overline{a}$, respectively. For $\frac{1}{2} < s \leq 1$, $i > \bar{i}$ so $n^* < \overline{n}$ and $a^* > \overline{a}$ whereas for $0 \leq s \leq \frac{1}{2}$, $i \leq \bar{i}$ so $n^* \geq \overline{n}$ and $a^* \leq \overline{a}$. Combining this with the first part of the proposition proves the second part. ■

Proposition 2 shows that a countercyclical monetary policy may increase the variability of bank competitiveness and of the lending rate over the business cycle. The intuition for this result stems from the fact that although s can take on different values, n^* and a^* are based on expected profits and therefore do not depend on the actual realization of s (say, the true state of the economy). Since n^* and a^* do depend on the policy rate i, a countercyclical monetary policy increases the variance of n^* and a^* from zero to a positive value. With respect to a^*, this is one of the aims of a countercyclical policy. However, we have shown that n^* is affected as well, and the competitiveness of the banking sector is varying more. This result can be related to that of Bagliano et al. (2000). In their model, an increase in the degree of countercyclicality leads to softer competition among banks in good states. This corresponds to our findings for $s > \frac{1}{2}$. However, for

$s < \frac{1}{2}$, we find the opposite effect, whereas in their model in bad states there is always full collusion.

Bagliano et al. (2000, pp. 977-978) argue that α, which can be interpreted as a feedback coefficient with respect to the state of the own economy, was high for Germany before EMU but relatively low for the other EMU-members. The reason is that these other members mainly had to adjust their monetary policy to the actions taken by the Bundesbank following German shocks. The shift to EMU may imply an increase in the feedback coefficient α for these other members, and a decrease in α for Germany. Our results thus predict that the shift to EMU might imply bank competitiveness to vary less in Germany but more in other member countries. Combined with the prediction of Bagliano et al. (2000, p. 979) that '... German banks might experience a comparatively larger increase in efficiency than their European counterparts,' this suggests that the German economy may benefit most from the introduction of EMU.

4 Discussion

The timing of the model can be interpreted as follows. First, in stage 1, the central bank sets the short-term interest rate i according to some policy rule. Then, in stage 2, banks decide whether or not to enter the market, driving their net profits to zero. This determines the number of banks n. After that, banks compete and set the lending rate a. In the formal model, banks compete for one period only (i.e. stage 3). Informally, however, we can think of banks competing for several, say T, periods. At the end of period T, the central bank decides to adjust the short-term interest rate for some reason (for example, after several periods of boom the central bank now expects a recession). After the new rate has been set, banks decide whether or not to enter (or exit) the market. Again, the banks compete for some time, until the central bank adjusts the interest rate again, etc.

A countercyclical monetary policy in our model has an external effect with respect to the strength of competition in the banking sector. In the model, we considered the equilibrium number of banks n^*, which was influenced by the policy rate i. Evidently, in reality, the number of active banks will not respond much to a short-run interest rate. Furthermore, barriers to entry (and exit) will cause the number of banks to be relatively stable. However, interpreting our result in terms of competitiveness, we see that a countercyclical monetary policy may imply a level of competition among banks that varies over time (i.e. over the business cycle). This has important implications for competition policy. In general, governments prefer well-functioning financial markets. Although there are several restrictions to bank competition, e.g. legal entry barriers, a government thus prefers competition in the banking sector to be as strong as possible (given those restrictions). The above analysis shows that when the central bank follows a countercyclical monetary policy rule, this preferred level of competition cannot always be achieved. A lack of competition at some point in time therefore should not always be blamed on the abuse of market power by banks; it may be due to the interest rate setting rule applied by the central bank.

We examined the effects of monetary policy on the equilibrium values n^* and a^*. In solving the model, we assumed that the central bank sets i based on the realization of the shock s in stage 1, but remarked that a timing problem occurs when doing so. Clearly, in order for i to affect n^* and a^* and thereby output, it should be chosen *before* n and a. However, this implies that s must be known to the central bank in stage 1, whereas it was assumed to be unknown to the public in stages 2 and 3. How can this timing problem be solved?[2] Of course, we can simply assume that the central bank knows

[2]A possible solution could be to use a repeated game in which the central bank sets i_t *after* the bank competition subgame, and where n_t^* and a_t^* are functions of i_{t-1}. However,

what the realization of s will be whereas commercial banks do not know, as we did in the previous section. A more realistic solution is discussed in Section 4.1.

In Section 4.2, we consider what happens if the condition $V - a^* - t\widehat{x} \geq 0$ is not satisfied and the loan market is not covered. In that case, the entrepreneur located at $\widehat{x}$ (and others located near $\widehat{x}$) will not want to borrow and undertake an investment project. Therefore, these entrepreneurs will not demand a loan. Because a high i set by the central bank may cause a^* to be so high that this condition is violated, we discuss here what happens in our model when monetary policy affects loan demand.

4.1 Monetary policy disclosing information

This subsection presents a possible solution to the timing problem described above. Suppose that the central bank sets i in stage 1, based on a *prediction* of s, $\widehat{s}$. That is, the monetary policy rule should be interpreted as

$$i = \bar{i}\left[1 + \alpha\left(2\widehat{s} - 1\right)\right] + \varepsilon.$$

If $\varepsilon \equiv 0$ (a purely countercyclical monetary policy), banks can infer the central bank's prediction $\widehat{s}$ from the interest rate i set in stage 1. In that case, if banks know the central bank to predict s correctly (so in fact, the value of s is known), i is completely informative with respect to s, and n^* and a^* will be based on the true value $\widehat{s}$ instead of the probability distribution function of s. In our model this implies that for very low $\widehat{s}$, as a bank's earnings fall below F even with only one bank, n^* will equal zero. This does not seem to be a realistic value for the number of active banks. Therefore, we assume i not to be completely informative with respect to s. This can happen when

the term 'countercyclical' suggests that s_t somehow depends on s_{t-1}. Imposing such a relationship would complicate the analysis, and therefore we choose not to use this approach.

ε can be different from zero, or when the banks believe that the prediction $\widehat{s}$ is not always correct. If banks find i completely uninformative (the other polar case), they will maximize expected profits based on the probability distribution function of s. This is exactly what we did in Section 3.

In the less extreme 'intermediate' case, banks find i somewhat informative. In order to model this, assume that the banks believe the central bank to predict s correctly with probability $0 < \varphi < 1$. Furthermore, for simplicity, let $\varepsilon \equiv 0$ and assume that after stage 2 it becomes known whether or not the central bank's prediction was correct. If the central bank does not predict s correctly, which happens with probability $1 - \varphi$, the estimate does not provide any information on the actual realization of s (or, at least, the banks believe this is the case). When considering entry a bank now considers

$$E_{\varphi}(\pi^*, \widehat{s}) = (1 - \varphi) E(\pi^*) + \varphi \pi(\widehat{s}),$$

where $\widehat{s}$ is the central bank's prediction for s inferred from the value of i using $i = \bar{i}\,[1 + \alpha(2\widehat{s} - 1)]$. We assume $E_{\varphi}(\pi^*, \widehat{s}) \geq F$ for some $n \geq 1$, in order to avoid the problem of $n^* = 0$ described above. In Section 3, we used $\varphi = 0$. How are the results affected if $0 < \varphi < 1$? Define s^c as the (critical) value of s for which $\pi(s^c) = E(\pi^*)$. Then we can derive the following result.

Proposition 3 *For $\widehat{s} < \min\left[s^c, \frac{1}{2}\right]$ and for $\widehat{s} > \max\left[s^c, \frac{1}{2}\right]$, the degree of countercyclicality of n^* is reduced by i being somewhat informative ($0 < \varphi < 1$). However, for $\widehat{s}$ in between s^c and $\frac{1}{2}$, the degree of countercyclicality of n^* is increased.*

Proof. For $\widehat{s} > s^c$, $\pi(\widehat{s}) > E(\pi^*)$, so $E_{\varphi}(\pi^*, \widehat{s}) > E(\pi^*)$. The optimal number of banks, n^*_{φ}, is determined by setting $E_{\varphi}(\pi^*, \widehat{s})$ equal to F. This implies $n^*_{\varphi} > n^*$. Similarly, for $\widehat{s} \leq s^c$ we find $n^*_{\varphi} \leq n^*$. Combining this with Proposition 2 and its proof, the result follows. ■

Our main conclusion remains valid. Although $\varphi > 0$ will amplify or weaken the effect depending on the size of $\widehat{s}$, the level of competition among banks may vary countercyclically with a countercyclical monetary policy. A similar result will hold if we do not use the simplifying assumptions that $\varepsilon \equiv 0$ and that after stage 2 the banks get to know whether or not the central bank's prediction was correct.

4.2 Monetary policy affecting loan demand

Above, we argued that the central bank will use a countercyclical monetary policy in order to increase (decrease) total sales or output in bad (good) states. Alternatively, one may want to consider a model in which the countercyclical monetary policy also affects the level of investments, i.e. total loan demand. Indeed, in our model, total loan demand is fixed. This assumption can be adjusted by assuming that a high a^* implies that some entrepreneurs do not want a loan because their sales generated by the loan, S_{lj}, become negative (or, because of limited liability, zero). In that case, if i is above some critical value i^c, the entrepreneurs located around $\widehat{x}$, say in the interval $[\widehat{x} - \delta(i), \widehat{x} + \delta(i)]$, prefer not to borrow at all. Demand is therefore given by

$$D_j(\cdot) = \begin{cases} 2(\widehat{x} - \delta(i)) & \text{for } i > i^c \\ 2\widehat{x} & \text{for } i \leq i^c \end{cases}$$

where $\delta(i)$ is an increasing function of i. Since this complicates the analysis, we will not study this demand function in detail. However, in general, for a given value of i we can say the following. If $i > i^c$, demand is decreased relative to our basic model, so n^* will be lower. For $i > \bar{i}$, this decrease in demand amplifies the countercyclical effect on n^*. However, if $i^c < i < \bar{i}$, the effect is weakened. This specification affects the monetary policy rule itself as well: for $i > i^c$ and $i > \bar{i}$, the central bank need not increase i as much as before to obtain the desired result for output. Still, the strength of bank competition may vary countercyclically due to the monetary policy rule chosen by the central bank.

5 Conclusion

Using the Salop model of monopolistic competition for banks offering heterogeneous loans, we have analyzed the effects on bank competition of the choice of a monetary policy rule by the central bank. We have shown that monetary policy can have an external effect on the strength of competition in the banking sector. This confirms the findings of Bagliano et al. (2000), who applied a model of implicit collusion to the banking sector. Although the precise effects in their model are different from ours (that is, for bad states of the world), we come to the same general conclusion that *"the type of monetary policy rule chosen by the monetary authorities tends to affect the degree of competitiveness in oligopolistic banking sectors. For this reason, monetary policy criteria that are designed to achieve some desired macroeconomic target may result in a 'softer', or 'tougher', credit-market competition"* (p. 979).

In our model, a countercyclical monetary policy implies a countercyclical movement of the number of active banks. More generally, this can be interpreted as a level of bank competition that varies over time (i.e. over the business cycle). With respect to competition policy, this indicates that a lack of competition in banking at some point in time cannot always be blamed on the abuse of market power; it may have its roots in the interest rate setting rule chosen by the central bank. The model predicts that the shift from EMS to EMU may decrease the variability of competitive strength of German banks, but increase this variability for other member countries.

Appendix: Proofs of Lemma's 1 and 2

In this appendix we briefly discuss the proofs of Lemma's 1 and 2.

Proof of Lemma 1 Remember that equation (3) implicitly defines n^* as a function of i and other parameters of the model. In order to find the comparative static effect of i on n^*, we totally differentiate this equation with respect to i and solve for $\frac{dn^*}{di}$. This gives $\frac{dn^*}{di} = \frac{A}{B}$ where

$$\begin{aligned} A &= -2\left(t-n-ni+\sqrt{X}\right)\left(-n+\frac{1}{2\sqrt{X}}\left(2n^2+2n^2i+6nt\right)\right) \\ &\quad +4Fn^2\left(n+\frac{1}{2\sqrt{X}}\left(2n^2+2n^2i+6nt\right)\right) \end{aligned}$$

and

$$\begin{aligned} B &= 2\left(t-n-ni+\sqrt{X}\right)\left(-1-i+\frac{1}{2\sqrt{X}}\left(2n+6t+4ni+2ni^2+6it\right)\right) \\ &\quad -4F[2n\left(t+n+ni+\sqrt{X}\right)+n^2\left(1+i\right) \\ &\quad +\frac{n^2}{2\sqrt{X}}\left(2n+6t+4ni+2ni^2+6it\right)]. \end{aligned}$$

Substituting for F using

$$\begin{aligned} F &= \frac{1}{2n}\frac{(a^*-i)^2}{1+a^*} \\ &= \frac{1}{2n}\frac{\left(\frac{1}{2n}\left(t-n+ni+\sqrt{X}\right)-i\right)^2}{1+\frac{1}{2n}\left(t-n+ni+\sqrt{X}\right)} \\ &= \frac{1}{4n^2}\frac{\left(t-n-ni+\sqrt{X}\right)^2}{t+n+ni+\sqrt{X}}, \end{aligned}$$

lengthy but straightforward calculations yield

$$\frac{dn^*}{di} = -\frac{2n\left(1+i\right)}{\left(t+3n+3ni\right)\sqrt{X}+t^2+3n^2+6nt+6n^2i+3n^2i^2+6nit} < 0$$

which proves the result.

Proof of Lemma 2 For a^*, we have the explicit expression (2). Taking the derivative of a^* with respect to i, we find

$$\begin{aligned}\frac{da^*}{di} &= -\frac{1}{2n^2}\left(t-n+ni+\sqrt{X}\right)\frac{dn^*}{di}+\frac{1}{2n}\frac{dn^*}{di}(-1+i+n) \\ &\quad +\frac{1}{2n}\frac{1}{2\sqrt{X}}\left[\frac{dn^*}{di}\left(2n+6t+4ni+2ni^2+6it\right)+2n^2+2n^2i+6nt\right].\end{aligned}$$

Multiplied by $2n\sqrt{X}>0$, this becomes

$$\frac{dn^*}{di}\left(-\frac{1}{2}t\sqrt{X}-\frac{1}{n}t^2-3t-3ti\right)+n\sqrt{X}+n^2+n^2i+3nt>0.$$

This proves the result.

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